10 Quality Acceptance & Data Processing

Since the 1960s, the Federal Highway Administration has encouraged Departments of Transportation and Contractors to use quality control and quality assurance (QA/QC) specifications, which are statistically based. Since then, a QA specification has become an important component in an organization's commitment to overall quality management. The QA specification is a combination of end-result specifications and materials and methods specifications.

The highway agency is responsible for the acceptance of the product that is produced by the Contractor who is implementing quality control in order to produce a product that meets the specifications provided by the agency. The Contractor is responsible for quality throughout hot mix asphalt production and placement. Therefore, the Contractor must ensure that the materials and work provided by subcontractors, suppliers, and producers are adequate and meet the specifications of the project.

In addition to assuring the production of a quality product, all personnel must also maintain accurate records throughout the production process. This is especially important when the data is being recorded for computer input and processing. In this chapter we provide specifics on VDOT's Quality Acceptance process and information to enable the accurate entry and processing of test results.

Learning Objectives:

Upon completion of this chapter, you should be able to:

- ☑ Describe the acceptance process
- ☑ Compare the mean test results of samples to acceptable standards
- ☑ Calculate the acceptance or failure for gradation and asphalt content
- ☑ Calculate adjustments on material failing gradation and asphalt content
- ☑ Compute the standard deviation of tests
- ☑ Follow data entry guidelines to ensure accurate data processing

Acceptance through Quality Assurance

	DEFINITIONS. The following terms will be used throughout this section:
Acceptance range	The job mix formula, with tolerances applied.
Adjustment	A reduction in unit bid prices on failing material.
Mean	The average of two or more numbers.
Quality assurance	The systematic monitoring and evaluation of various aspects of a project, to maximize the probability that minimum standards of quality are being attained by the production process.

The Quality Assurance (QA) process typically consists of several activities including: process control, acceptance, and sometimes independent assurance of product (Buttlar and Harrell, 1998)[1]. Figure 10-1 illustrates common components of the QA/QC process. Many of these have already been discussed in previous chapters. In this chapter we will examine the quality assurance, adjustment, and acceptance components.

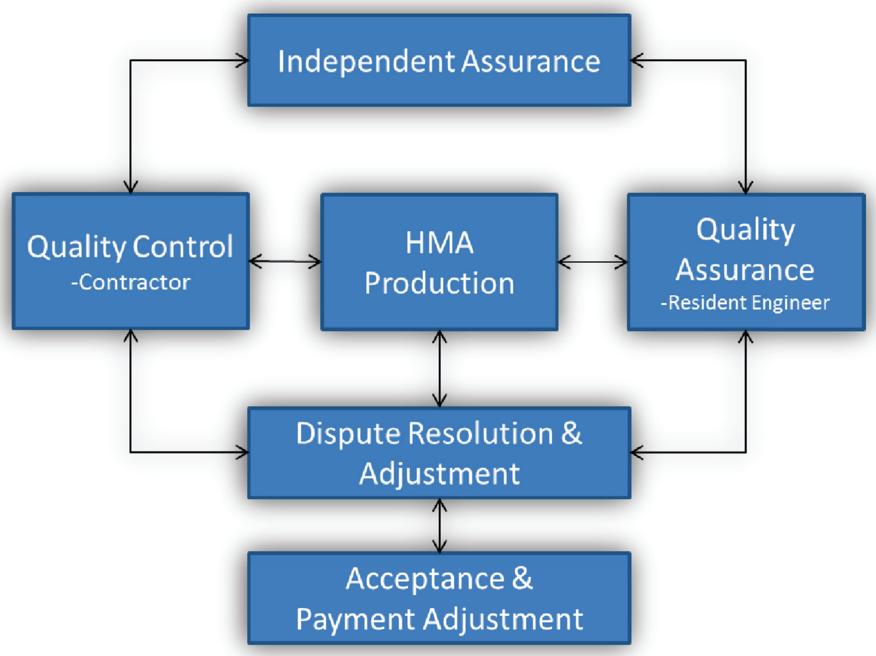

Figure 10-1: Component of QA/QC Programs

[1] Buttlar, W.G., and Harrell, M. (1998). Development of End-Result and Performance-Related Specifications for Asphalt Pavement Construction in Illinois. Transportation Conference Proceedings, pp 195-202.

QA Specifications

QA specifications typically are statistically based specifications designed to reward good quality and penalize poor quality. These specifications use methods such as random sampling, in which the properties of the desired products or constructions are described by appropriate statistical parameters and lot-by-lot testing. These methods help the contractor know whether or not the operations are producing the acceptable product.

Acceptance

Acceptance will be made under the Department's quality assurance program, which includes the testing of

- Production samples by the Contractor
- Monitor samples by the Department.

Acceptance Activities

The following critical activities must be performed by the Contractor and Department, respectively.

Performed by the Contractor	Performed by the Department
Sampling and testing for the determination of gradation, asphalt cement, content, and mix temperature	Perform independent monitor checks at a laboratory of its discretion
Provide copies of such test results to the Department on forms furnished by the Department	Review test results

Test Results Indicate Mixture Conformance to Specifications

If the Contractor's test results indicate that the mixture conforms to the gradation, asphalt cement, content and mix temperature requirements of the Specifications, the mixture will be acceptable for these properties. However, nothing herein shall be construed as waiving the requirements of Sections 106.06, 200.02 and 200.03, and 315 or relieving the Contractor of the obligation to furnish and install a finished functional product which conforms to the requirements of the contract.

Test Results Indicate a Statistically-Significant Difference

If a statistical comparative analysis of the Contractor's test results and the Department's monitor tests indicate a statistically significant difference in the results and *either* of the results indicates that the material does not conform to the grading and asphalt cement content requirements of the Specifications, an investigation will be made to determine the reason for the difference. In the event it is determined from the investigation that the material does *not* conform to the requirements of the contract, price adjustments will be made in accordance with the requirements of Section 211.09.

Basis for Acceptance for Gradation and Asphalt Cement Content

Acceptance for gradation and asphalt cement content will be based on the mean of the results of eight tests performed on samples taken in a stratified random manner from each 4000 ton lot. (Note: 8000 ton lots may be used when the normal daily production of the source from which the material is being obtained is in excess of 4000 tons.)

AWARENESS/IMPORTANT

Unless otherwise approved by the Engineer, samples shall be obtained from the approximate center of the truckload of material.

Highlights a step in the procedure which is either unusual or very particular to this procedure.
May also indicate awareness (additional information) or a cautionary concern in the procedure.

Any statistically acceptable method of randomization may be used to determine when to take the stratified random sample; however, the Department shall be advised of the method to be used prior to beginning production.

A lot will be considered to be acceptable for gradation and asphalt content if the mean of the test results obtained is within the tolerance allowed for the job mix formula as specified in Table II-15, shown here as Figure 10-2.

Table II-15
PROCESS TOLERANCE

Number of Tests	Top Size[1]	1 1/2	1	3/4	1/2	3/8	No. 4	No. 8	No. 30	No. 50	No. 200	A.C.
1	0.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0	5.0	2.0	0.60
2	0.0	5.7	5.7	5.7	5.7	5.7	5.7	5.7	4.3	3.6	1.4	0.43
3	0.0	4.4	4.4	4.4	4.4	4.4	4.4	4.4	3.3	2.8	1.1	0.33
4	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	2.5	1.0	0.30
5	0.0	3.6	3.6	3.6	3.6	3.6	3.6	3.6	2.7	2.2	0.9	0.27
6	0.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	2.4	2.0	0.8	0.24
7	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.3	1.9	0.7	0.23
8	0.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.1	1.8	0.7	0.21
12	0.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	1.7	1.4	0.6	0.17

[1] Defined as the sieve that has 100% passing as defined in Table II-13.

Figure 10-2: Tolerance on Each Laboratory Sieve and Asphalt Content – Percent Plus and Minus

If the job mix formula is modified within a lot, the mean test results of samples taken will be compared to the applicable process tolerance shown in Figure 10-2.

INSPECTION AND MEASUREMENTS

Visual Examination

Should visual examination by the Engineer reveal that the material in any load or portion of the paved roadway is obviously contaminated or segregated, that load or portion of the paved roadway will be rejected without additional sampling or testing of the lot.

Describes inspection, Quality Assurance and/or Quality Control practices.

If it is necessary to determine the gradation or asphalt content of the material in any load or portion of the paved roadway, samples will be taken, tested, and the results compared to the requirements of the approved job mix formula.

AWARENESS/IMPORTANT

The results obtained in the testing will apply only to the material in question.

Highlights a step in the procedure which is either unusual or very particular to this procedure.
May also indicate awareness (additional information) or a cautionary concern in the procedure.

Acceptance Calculations for Gradation and Asphalt Content

As previously stated, acceptance for gradation and asphalt content will be based on a mean (average) of the results of tests performed on samples taken in a stratified random manner from each lot.

Calculating the Acceptance or Failure for Gradation and Asphalt Content

STEP 1. Obtain the job mix formula.

a. The job mix formula is found on Form TL-127 (see Chapter 7) as submitted by the Contractor/Technician for the type mixture being produced.
b. Each approved job mix formula shall remain in effect, provided the results of tests performed on material currently being produced consistently meet the requirements of the job mix for grading, asphalt content, temperature, Superpave compaction results, and the requirements of Section 315.

STEP 2. Determine the number of tests performed on the quantity of material tested for acceptance. Usually the quantity of material tested for acceptance is a lot (4000 or 8000 tons), which requires 8 tests (one for every 500 or 1000 tons).

Example: Lot = 4000 or 8000 tons = 8 Tests

STEP 3. Calculate the acceptance range, as illustrated in Figure 10-3. To calculate the acceptance range, the process tolerance for the number of tests performed is applied to the job mix. Acceptance Range = Job Mix Process Tolerance

Example: (8 Tests) Type Mix: IM-I9.0A

Job Mix Sieves	Job Mix Formula Total % Passing	Process Tolerance for 8 Tests	Acceptance Range
1 in.	100.0	± 0.0	100
3/4 in.	98.0	± 2.8	95.2 – 100
1/2 in.	78.0	± 2.8	75.2 – 80.8
No. 8	47.0	± 2.8	44.2 – 49.8
No. 200	4.0	± 0.7	3.3 – 4.7
Asphalt	5.4	± 0.21	5.19 – 5.61

Figure 10-3: Calculating the Acceptance Range

STEP 4. Calculate the mean (average) of the test results for *each* job mix sieve, and asphalt content, as is illustrated in Figure 10-4.

$$\text{Mean (average)} = \frac{\text{Sum of Test Results}}{\text{Number of Tests}}$$

Sample No.	1	2	3	4	5	6	7	8	Aver.	Accept. Range Lower	Accept. Range Upper	Job Mix
1 in.	100	100	100	100	100	100	100	100	100	100	100	100
3/4 in.	97	96	98	97	95	99	98	97	97.1	95.2	100	98
1/2 in.	76	74	77	80	75	79	75	78	76.8	75.2	80.8	78
No. 8	45	44	49	47	46	43	50	46	46.3	44.2	49.8	47
No. 200	3	5	4	4	3	4	5	4	4	3.3	4.7	4
Asphalt	5	5.2	5.41	5.29	5.31	5.1	5.4	5.1	5.23	5.19	5.61	5.4

Figure 10-4: Calculating the Mean of the Test Results

STEP 5. Compare the mean (average) of the test results to the acceptance range

Example: The averages of the above lot are within the acceptance range.

Conclusion: This lot passes.

Adjustment System

DEFINITION

Adjustment

A reduction in unit bid price on failing material.

Describes and/or defines terminology.

In the event a lot of material does not conform to the acceptance requirements, one adjustment point will be applied for each 0.1% that the material is out of the process tolerance for asphalt content, as shown in Figure 10-5. This means that 10 adjustment points will be applied for each 1% that the material is out of conformance.

Sieve Size	Adjustment Points For Each 1% that the Gradation Is Outside The Process Tolerance Permitted In Table II-15 (Applied in 0.1 Increments)
2 in	1
1 ½ in	1
1 in	1
3/4 in	1
1/2 in	1
3/8 in	1
No. 4	1
No. 8	1
No. 30	2
No. 50	2
No. 200	3
Asphalt Content	10

Figure 10-5: Adjustment Points

Adjustment Conditions and Actions

The decision table that follows illustrates actions that will be taken for specific adjustment conditions.

Adjustment Condition	Adjustment Action
IF the total adjustment for a lot is greater than twenty-five (25) points…	…***THEN*** the failing material shall be removed from the road
IF the total adjustment is twenty-five (25) points or less… ***AND*** the Contractor does not elect to remove and replace the material…	…***THEN*** the unit price paid for the material will be reduced 1% of the unit price bid for each adjustment point

AWARENESS/IMPORTANT

The adjustment will be applied to the tonnage represented by the sample or samples. In the event adjustment points are applied against two (2) successive lots, plant adjustment shall be made prior to continuing production.

Highlights a step in the procedure which is either unusual or very particular to this procedure.
May also indicate awareness (additional information) or a cautionary concern in the procedure.

Calculating Adjustments on Material Failing Gradation and Asphalt Content

Follow the steps in this section to determine how to calculate adjustments on material failing gradation and asphalt content. For the purpose of this example, assume: **Type Mix SM -12.5A.**

					Accept. Range			
Sample No.	**1**	**2**	**3**	**Average**	**Lower**	**Upper**	**Job mix**	**P/F**
3/4 in	100	100	100	100	100	100	100	
1/2 in	100	98	97.0	98.3	94.6	100	99	
3/8 in	85	87	83.0	85.0	81.6	90.4	86	
No. 8	49	53	52.0	51.3	52.6	61.4	57	**F**
No. 200	3.6	4.3	4.1	4.0	4.9	7.1	6	**F**
Asphalt	5.3	5.22	5.23	5.25	5.37	6.03	5.7	**F**

STEP 1. Compute the adjustment on the No. 8 (2.36mm) sieve.

Refer to the adjustment point table for gradation and note that, for the No. 8 (2.36mm) sieve, a point adjustment for each 1% that the gradation is outside the acceptance range is applied.

52.6	Lower Acc. Range	1.0	Adjustment for Each 1%
-51.3	Average #8 (2.36mm) Sieve	x1.3%	Outside Acc. Range
1.3%	Outside Acc. Range	1.3%	Adjustment #8 (2.36mm) Sieve

STEP 2. Compute the adjustment on the No. 200 (75 µm) sieve.

Refer to the adjustment point table for gradation and note that for the No. 200 (75 µm) sieve, a 3-point adjustment for each 1% that the gradation is outside the acceptance range is applied.

4.9	Lower Acc. Range	3.0	Adjustment for Each 1%
- 4.0	Average #200 (75 µm) Sieve	x 0.9%	Outside Acc. Range
0.9%	Outside Acc. Range	2.7%	Adjustment #200 (75 µm) Sieve

STEP 3. Compute the adjustment on asphalt content.

Refer to the specifications and note that one adjustment point will be applied for each 0.10% that the material is outside of the acceptance range. This statement means than 10 adjustment points will be applied for each 1% that the material is outside the acceptance range.

5.37	Lower Acc. Range	10	Adjustment for Each 1%
-5.25	Average Asphalt Content	x 0.12%	Outside Acc. Range
0.12%	Outside Acc. Range	1.2%	Adjustment Asph. Content

STEP 4. Compute the total adjustment.

The total adjustment is the sum of the adjustments for gradation and asphalt content.

1.3 %	Adjustment #8 (2.36 mm) Sieve
2.7 %	Adjustment#200 (75 µm)
+1.2 %	Adjustment Asphalt Content
5.2 %	Total Adjustment for Gradation and Asphalt Content

Conclusion: An adjustment of 5.2 points should be applied to this lot.

Standard Deviation (Calculation of Variability)

Standard deviation is a measure of variability indicating the amount of variation from the mean. The Contractor shall control the variability of his product in order to furnish a uniform mix. When the quantity of any one type material furnished by a project exceeds 4000 tons, the variability of the total quantity furnished will be measured by calculating the standard deviation for each sieve size and the asphalt content.

In the event the standard deviation is within the limits shown in the Standard Deviation Table II-16 (Figure 10-6), the unit bid price for the material will be reduced by 0.5% for each adjustment point applied.

AWARENESS/IMPORTANT

Standard deviation computations will not be made separately on more than two job mixes for the same type material, unless a change is requested by VDOT.

Highlights a step in the procedure which is either unusual or very particular to this procedure.
May also indicate awareness (additional information) or a cautionary concern in the procedure.

Table II-16
STANDARD DEVIATION
(Determination of Variability)

Sieve Size and Asphalt Content	1 adjustment point for each sieve size and asphalt content	2 adjustment points for each sieve size and asphalt content	3 adjustment points for each sieve size and asphalt content
1/2 inch	3.8 – 4.7	4.8 – 5.7	5.8 – 6.7
3/8 inch	3.8 – 4.7	4.8 – 5.7	5.8 – 6.7
No. 4	3.8 – 4.7	4.8 – 5.7	5.8 – 6.7
No. 8	3.0 – 3.9	4.0 – 4.9	5.0 – 5.9
No. 30	2.2 – 3.1	3.2 – 4.1	4.2 – 5.1
No. 50	1.5 – 2.4	2.5 – 3.4	3.5 – 4.4
No. 200	1.1 – 2.0	2.1 – 3.0	3.1 – 4.0
Asphalt Content	0.27 – 0.36	0.37 – 0.46	0.47 – 0.56

Figure 10-6: Standard Deviation Chart

The disposition of material having standard deviations larger than those shown in Table II-16 will be determined by the Engineer.

Computing Standard Deviations

Standard deviation is usually designated by the Greek symbol **σ**. In mathematical equation form standard deviation is equal to:

$$\sigma = \sqrt{\frac{\Sigma (X - \bar{X})^2}{n - 1}}$$

Where: Σ = sum of

X = the individual test results

$\bar{X}$ = the average of all test results

n = the number of test results

While the formula may look complicated, the actual computing of the standard deviation is simple. The following example shows the procedure which should be used.

Example Computation

Given the following four test results for the No.8 (2.36mm) sieve, SM-9.5A mix:

Test #1 - 59.3%, Test #2 - 53.1%, Test #3 - 64.7%, Test #4 - 55.7%.

Find:

n $\quad X$ $\quad \bar{X}$ $\quad X - \bar{X}$ $\quad (X - \bar{X})^2$

STEP 1. Set up a table as shown below. In the column headed **Sample Number**, list 1, 2, 3, 4, since there were four tests. The last cell in this column should read "**SUM**."

Sample Number	**X**	$\bar{X}$	$X - \bar{X}$	$(X - \bar{X})^2$
1				
2				
3				
4				
SUM				

STEP 2. In the column headed **X**, list the individual test results in the problem.

Sample Number	X	$\overline{X}$	$X - \overline{X}$	$(X - \overline{X})^2$
1	59.3			
2	53.1			
3	64.7			
4	55.7			
SUM				

STEP 3. Add the results in the **X** column and place the total (**232.8**) in the final row for that column.

Sample Number	X	$\overline{X}$	$X - \overline{X}$	$(X - \overline{X})^2$
1	59.3			
2	53.1			
3	64.7			
4	55.7			
SUM	232.8			

STEP 4. Divide this total by the number of tests (n), which in this case n = 4. This gives an average percent passing the No.8 (2.36mm) sieve of **58.20**. Place this value in all of the test rows of the **X** column.

Note: The average should always be shown to the nearest one-hundredth of a percent (two decimal places).

Sample Number	X	$\overline{X}$	$X - \overline{X}$	$(X - \overline{X})^2$
1	59.3	58.20		
2	53.1	58.20		
3	64.7	58.20		
4	55.7	58.20		
SUM	232.8			

STEP 5. Subtract the values in the $\overline{\mathbf{X}}$ column from those in the **X** column and record these values in the $\mathbf{X} - \overline{\mathbf{X}}$ column

As a check, the values in this column can be added algebraically and should equal zero, except in cases where the average is not exact and has been rounded off to two decimal places.

Sample Number	X	$\overline{X}$	$X - \overline{X}$	$(X - \overline{X})^2$
1	59.3	58.20	+1.10	
2	53.1	58.20	-5.10	
3	64.7	58.20	+6.50	
4	55.7	58.20	-2.50	
SUM	232.8		0.00	

STEP 6. Square the values in the $\mathbf{X} - \overline{\mathbf{X}}$ column and record these values in the $\mathbf{(X - \overline{X})^2}$ column.

1.10 x 1.10 = 1.2100

5.10 x 5.10 = 26.0100

6.50 x 6.50 = 42.2500

2.50 x 2.50 = 6.2500

Sample Number	X	$\overline{X}$	$X - \overline{X}$	$(X - \overline{X})^2$
1	59.3	58.20	+1.10	1.2100
2	53.1	58.20	-5.10	26.0100
3	64.7	58.20	+6.50	42.2500
4	55.7	58.20	-2.50	6.2500
SUM	232.8		0.00	

STEP 7. Add the **($X - \bar{X}$)** column and record the value of **75.7200** as shown.

Sample Number	X	$\bar{X}$	$X - \bar{X}$	$(X - \bar{X})^2$
1	59.3	58.20	+1.10	1.2100
2	53.1	58.20	-5.10	26.0100
3	64.7	58.20	+6.50	42.2500
4	55.7	58.20	-2.50	6.2500
SUM	232.8		0.00	75.7200

STEP 8. Divide this value by the number of samples (n) minus 1.

In this case there are 4 samples, so (n-1) = 4 - 1 = 3.

75.7200/ 3 = 25.2400

STEP 9. Finally, determine the square root of **25.2400**, the value calculated from Step 8.

$$\sqrt{25.2400} = 5.02$$

$$\sigma = 5.02$$

This is the standard deviation of the four test results:

$$\sigma = \sqrt{\frac{\sum (X - \bar{X})^2}{n - 1}}$$

$$\sum (X - \bar{X})^2 = 75.72$$

$$\frac{\sum (X - \bar{X})^2}{n - 1} = \frac{75.7200}{4 - 1} = \frac{75.7200}{3} = 25.400$$

$$\sqrt{25.2400} = 5.02$$

<u>Conclusion</u>: The standard deviation (σ) equals **5.02**

AWARENESS/IMPORTANT

Variability cannot be computed for a single (1) sample, because one sample will have no variability.

Highlights a step in the procedure which is either unusual or very particular to this procedure.
May also indicate awareness (additional information) or a cautionary concern in the procedure.

Automated Data Processing for Asphalt Concrete

The purpose of the data system for which these instructions were prepared is to provide descriptive information about the materials used in highway work.

The data processing system is designed for coding test reports. For instance, in lieu of recording the Contractor’s name and location, only a 4-digit code will be required. The printout will show the Contractor’s name and location. The codes may be obtained from the District Materials Section.

It is very important for the success of the computer program that all data entered on the Data Processing Forms:

- Is correct
- Is placed in the proper blanks
- Is legible

As a rule, numeric characters are recorded from the right to left and alphabetic from the left to right. Please adhere to these standards.

When the coding input forms have been completed by the Contractor/Technician, they should be submitted to the District Materials Section for review and processing. After processing, the forms will be retained by the District Materials Section for the duration of the project.

Completing Form TL-100A – The Asphalt Test Results Input Form

The records input data are self-explanatory, based on the field names on this report. There are eight data records, which allow for the entry of the test data for eight tests, which is the normal lot size (see revised Road & Bridge Specifications 211.09, Adjustment System).

Simply enter the codes and/or test data where specified.

The codes for the contracts will be put on the forms by the Department, as illustrated by Figure 10-7 on the next page.

ASPHALT CONCRETE - TEST RESULTS INPUT FORM

INPUT SUBMITTED BY: J. D.Harris | DATE SUBMITTED: 8/26/2010 | PHONE NUMBER: 512-6712

PLANT ID: 1048

JOB MIX NUMBER:	201004	PROJECT # :	TONS:	PROJECT # :	TONS:
LOT:	201001	PM-1F-05	4000		
MIX TYPE:	SM12-5A				
MIX CODE:	150				

REPORT # 51-1048-1685

SAMPLE #	TON	DATE MMDDYY	TIME HH:MM	2 in	1.5 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	#4	#8	#30	#50	#200	A.C.	TEMP	C F	MIX TIME	ASPH CEM.	VDOT
1	193	8/23/2010	9:10	100%	100%	100%	100%	98%	89%		35%			7.0%	5.78%	310	F	27	1	x
2	699	8/23/2010	13:50	100%	100%	100%	100%	98%	92%		38%			5.9%	6.30%	320	F	27	1	
3	1390	8/24/2010	8:41	100%	100%	100%	100%	100%	92%		40%			7.2%	6.05%	320	F	27	1	x
4	1830	8/24/2010	13:18	100%	100%	100%	100%	99%	92%		40%			6.6%	5.81%	310	F	27	1	
5	2361	8/24/2010	15:25	100%	100%	100%	100%	99%	91%		38%			6.5%	5.96%	315	F	27	1	
6	2640	8/25/2010	8:25	100%	100%	100%	100%	99%	89%		38%			6.3%	6.12%	317	F	27	1	x
7	3290	8/25/2010	11:00	100%	100%	100%	100%	100%	93%		37%			5.7%	6.08%	320	F	27	1	
8	3794	8/25/2010	13:49	100%	100%	100%	100%	98%	91%		37%			6.4%	6.02%	315	F	27	1	x

Volumetric Data	VTM	VMA	VFA	F/be	Gmm	VCAmix (SMA Only)	Comments
1	3.51%	15.8%	77.8%	1.11	2.503		
2							
3	2.90%	15.5%	81.3%	1.20	2.501		
4							
5	4.02%	16.4%	75.5%	1.10	2.507		
6							
7	3.89%	16.4%	76.3%	1.14	2.500		
8							

Figure 10-7: The Asphalt Concrete Test Results Input Form

Specification Reference Tables

Specification tables for use in completing calculations are reproduced here for ease of access.

Table II -13
ASPHALT CONCRETE MIXTURES-DESIGN RANGE
Percentage by Mass Passing Square Mesh Sieves

Mix Type	2 in.	1 ½ in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No. 30	No. 50	No. 200
SM-9.0 A,D,E					100	90-100	90 max	47-67			2-10
SM-9.5 A,D,E					100	90-100	80 max	38-67			2-10
SM-12.5 A,D,E				100	95 -100	90 max		34-50			2-10
IM-19.0 A,D,E			100	90-100	90 max			28-49			2-8
BM-25.0		100	90-100	90 max				19-38			1-7
C (curb mix)					100	92-100	70-75	50-60	28-36	15-20	7-9

Legend:
SM = Surface Mixture; IM = Intermediate Mixture, BM = Base Mixture, C = Curb Mixture
** A production tolerance of 1% will be applied to this sieve, regardless of the number of tests in the lot.*

Table II-15
PROCESS TOLERANCE

Number of Tests	Top Size[1]	1 1/2	1	3/4	1/2	3/8	No. 4	No. 8	No. 30	No. 50	No. 200	A.C.
1	0.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0	5.0	2.0	0.60
2	0.0	5.7	5.7	5.7	5.7	5.7	5.7	5.7	4.3	3.6	1.4	0.43
3	0.0	4.4	4.4	4.4	4.4	4.4	4.4	4.4	3.3	2.8	1.1	0.33
4	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	2.5	1.0	0.30
5	0.0	3.6	3.6	3.6	3.6	3.6	3.6	3.6	2.7	2.2	0.9	0.27
6	0.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	2.4	2.0	0.8	0.24
7	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.3	1.9	0.7	0.23
8	0.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.1	1.8	0.7	0.21
12	0.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	1.7	1.4	0.6	0.17

[1] Defined as the sieve that has 100% passing as defined in Table II-13.

Sieve Size	Adjustment Points For Each 1% that the Gradation Is Outside The Process Tolerance Permitted In Table II-15 (Applied in 0.1 Increments)
2 in	1
1 ½ in	1
1 in	1
3/4 in	1
1/2 in	1
3/8 in	1
No. 4	1
No. 8	1
No. 30	2
No. 50	2
No. 200	3
Asphalt Content	10

Table II-16
STANDARD DEVIATION
(Determination of Variability)

Sieve Size and Asphalt Content	1 adjustment point for each sieve size and asphalt content	2 adjustment points for each sieve size and asphalt content	3 adjustment points for each sieve size and asphalt content
1/2 inch	3.8 – 4.7	4.8 – 5.7	5.8 – 6.7
3/8 inch	3.8 – 4.7	4.8 – 5.7	5.8 – 6.7
No. 4	3.8 – 4.7	4.8 – 5.7	5.8 – 6.7
No. 8	3.0 – 3.9	4.0 – 4.9	5.0 – 5.9
No. 30	2.2 – 3.1	3.2 – 4.1	4.2 – 5.1
No. 50	1.5 – 2.4	2.5 – 3.4	3.5 – 4.4
No. 200	1.1 – 2.0	2.1 – 3.0	3.1 – 4.0
Asphalt Content	0.27 – 0.36	0.37 – 0.46	0.47 – 0.56

Chapter Ten Knowledge Check

1. A mathematical analysis of accumulated data is called:
    A. Design range
    B. Statistics
    C. Viscosity
    D. Process tolerance

2. The job mix formula with the tolerance applied is the:
    A. Reference guide
    B. Acceptance range
    C. Control guide
    D. Process tolerance

3. The quantity of material to be checked for compliance with specifications is called:
    A. Gradation
    B. A lot
    C. The referee system
    D. The design range

4. The job mix formula is chosen from the:
    A. Standard deviation range
    B. Design range
    C. Process tolerance range
    D. Acceptance range

5. A reduction in the unit bid price of material is known as:
    A. The standard deviation
    B. A control guide
    C. A price adjustment
    D. The design range adjustment.

6. When the normal daily production of the source from which asphalt concrete is being obtained is in excess of 4000 tons, the lot size may be increased to:
    A. 2000 tons
    B. 3000 tons
    C. 8000 tons
    D. 5000 ton

7. Standard deviation computations are not normally made on more than two job mixes for the same type material on a single project.
    A. True
    B. False

8. The amount of deviation allowed from the job mix formula is known as the:
    A. Design range
    B. Process tolerance
    C. Weigh tolerance
    D. Standard deviation

9. How many adjustment points may a material have and still remain in the road?
    A. More than 30
    B. More than 25
    C. 25 or less
    D. None of the above

10. Variability can be computed on any number of samples except:
    A. One
    B. Two
    C. Three
    D. None of the above

11. Would the process tolerance be the same for three tests as a lot with eight tests?
    A. Yes
    B. No

12. After running analysis on a sample, how is it checked for conformity with specifications?

13. On a failing lot, who is responsible for applying the adjustment points?

14. If a job mix is in the design range, can it be disapproved?

15. Where are the standard deviation limits found for asphalt concrete?

16. What number of adjustment points constitutes the removal of the material from the road?

17. Why is it important that a Producer know what the product variability is at all times?

18. Calculations for the gradation of aggregate in the mixture are shown to what percent? What percent is the asphalt content?

19. What, if any adjustment points would be applied to a mix if the standard deviation for the No.200 material is 2.3?

Problem No.1

Using the information given below, complete the Form TL-100A on the next page.

Producer: Flatt Top Paving Company - code 1048

Wet Mixing Time: 27 seconds

Asphalt Cement Supplier: Alright Asphalt Products - code 23.

Lot 7 - 2000 tons

The material is being shipped to PM-1L-05.

Job Mix Information: Type SM-12.5A mix code number - 15

Job Mix Number: 201003

Test Results	#1	#2	#3	#4
Date	8-27-10	8-27-10	8-28-10	8-28-10
Time	10:00	13:30	8:17	11:05
Ton	210	710	1224	1820
Mix Temp.	310 °F	310 °F	305 °F	308 °F
3/4 in	100	100	100	100
1/2 in	98.4	99.4	98.5	99.2
3/8 in	87.1	83.5	81.1	87.3
No. 8	48.7	46.7	44.2	50.2
No. 200	5.3	4.7	5.7	5.5
A.C.	5.63	5.57	5.06	5.15
VTM	4.40		3.61	
VMA	16.2		15.3	
VFA	72.8		76.4	
F/P_{be}	1.0		1.2	
G_{mm}	2.479		2.494	

TL-100A
REV: 03/2010

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
ASPHALT CONCRETE - TEST RESULTS INPUT FORM

INPUT SUBMITTED BY: ______ **DATE SUBMITTED:** ______ **PHONE NUMBER:** ______
PLANT ID: ______

JOB MIX NUMBER:		**PROJECT # :**	**TONS:**	**PROJECT # :**	**TONS:**
LOT:					
MIX TYPE:					
MIX CODE:					
REPORT #					

SAMPLE #	TON	DATE *MMDDYY*	TIME *HH:MM*	2 in	1.5 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	#4	#8	#30	#50	#200	A.C.	TEMP	C F	MIX TIME	ASPH CEM.	VDOT
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				

Volumetric Data	VTM	VMA	VFA	F/be	Gmm	VCAmix (SMA Only)	Comments
1							
2							
3							
4							
5							
6							
7							

Problem No. 2: Failure and Adjustment

Using the information given below, calculate the failure and adjustment.

The producer is Flatt Top Paving Company and the plant is a batch plant and operates on a 27 second wet mixing time. It has been assigned to Code Number 777. The material is being shipped to Schedule No. 777-75, Item N. The asphalt cement is delivered from terminal No. 15. The samples represent Lot 1, which contains 2000 tons.

Job Mix Information: Type SM-12.5A

Mix code number - 16

Job Mix Number - 9202

Job Mix	
3/4 in	100.0
1/2 in	97.0
3/8 in	88.0
No. 8	55.0
No. 200	5.5
A.C.	5.50

Test Results:	Sample #1	Sample #2	Sample #3	Sample # 4	Avg.	Acc. Range
Date	8-27-10	8-27-10	8-28-10	8-28-10		
Time	10:00	13:30	8:17	11:05		
Ton	210	710	1224	1820		
Mix Temp.	310 °F	310 °F	305 °F	308 °F		
3/4 in	100.0	100.0	100.0	100.0		
1/2 in	98.4	99.4	98.5	99.2		
3/8 in	87.1	83.5	81.1	87.3		
No. 8	48.7	46.7	44.2	50.2		
No. 200	5.3	4.7	5.7	5.5		
A.C.	5.63	5.57	5.06	5.15		

Problem No. 3: Computing Standard Deviation

Using the information given below, determine the variability of the # 200 sieve.

Test Results:	**Sample #1**	**Sample #2**	**Sample #3**	**Sample #4**
Date	8-27-10	8-27-10	8-28-10	8-28-10
Time	10:00	13:30	8:17	11:05
Ton	210	710	1224	1820
Mix Temp.	310°F	310°F	305°F	308°F
3/4 in	100.0	100.0	100.0	100.0
1/2 in	98.4	99.4	98.5	99.2
3/8 in	87.1	83.5	81.1	87.3
No. 8	48.7	46.7	44.2	50.2
No. 200	5.3	4.7	5.7	5.5

$$\sigma \quad \sqrt{\frac{\sum (X - \overline{X})^2}{n - 1}}$$

Sample #	**X**	$\overline{\textbf{X}}$	$\textbf{X} - \overline{\textbf{X}}$	$(\textbf{X} - \overline{\textbf{X}})^2$
SUM =				

Problem No. 4: Computing Price Adjustment for Variability as measured by Standard Deviation

A. Complete the following test report and if the material fails, indicate area(s) of failure. If the material can be accepted with adjustment, calculate the percent of adjustment.

Sample #	1	2	3	4	Aver.	Accept. Range		Job Mix	P/F
						Lower	Upper		
1 1/2 in	100.0	100.0	100.0	100.0				100.0	
1 in	97.2	100.0	98.4	99.3				98.0	
3/4 in	73.1	78.2	79.2	75.1				76.0	
No. 8	29.2	32.1	28.3	36.2				33.0	
No. 200	3.2	5.6	4.7	3.9				4.0	
A.C.	4.68	4.83	5.00	5.27				4.40	

B. Using the test report above, determine the variability of the No. 8 (2.36mm) sieve by calculating the standard deviation. Determine if the variability meets the specification requirements. If not, how many adjustment points would be applied?

$$\sigma = \sqrt{\frac{\sum (X - \overline{X})^2}{n - 1}}$$

Sample #	X	$\overline{X}$	$X - \overline{X}$	$(X - \overline{X})^2$
SUM =				

Problem No. 5: Computing Price Adjustment for Variability as measured by Standard Deviation

A. Complete the following test report and if the material fails, indicate area(s) of failure. If the material can be accepted with adjustment, calculate the percent of adjustment.

					Accept. Range			
Sample #	**1**	**2**	**3**	**Aver.**	**Lower**	**Upper**	**Job Mix**	**P/F**
1 1/2 in	100.0	100.0	100.0				100.0	
1 in	94.3	97.7	99.1				98.0	
3/4 in	73.5	76.1	78.9				76.0	
No. 8	28.5	35.1	30.7				33.0	
No. 200	3.6	4.9	4.3				4.0	
A.C.	4.67	4.82	4.91				4.40	

B. Using the test report above, determine the variability of the No. 8 (2.36mm) sieve by calculating the standard deviation. Determine if the variability meets the specification requirements. If not, how many adjustment points would be applied?

$$\sigma = \sqrt{\frac{\sum (X - \overline{X})^2}{n - 1}}$$

Sample #	**X**	$\overline{X}$	**X –** $\overline{X}$	**(X –** $\overline{X}$**)²**
SUM =				

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